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LTSS

Livermore
Time-Sharing
System

MASTER

Part I: Octopus
Chapter 3: Teletypewriters
John G. Fletcher
Marilyn D. Richards
Pierre Du Bois
Edition 3 — April 15, 1972



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Chapter 3: Teletypewriters

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Pierre Du Bois

Edited by Keith A. Dawson

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Introduction

In order to control a program executing in a worker computer, an Octopus user exchanges messages with that computer through an interactive I/O terminal. Most interactive terminals are teletypewriters, which are joined to Octopus through the teletypewriter subnetwork described in LTSS-Ø. The behavior of each teletypewriter is closely associated with the operation of the PDP-8 concentrator, or Tentacle, to which it is attached.

Study of this chapter should provide all necessary information for the proper use of the most ubiquitous type of interactive terminal — the teletypewriter.

1. Teletypewriter Terminals

1.1 PHYSICAL CHARACTERISTICS

A teletypewriter is an electromechanical device much like a typewriter in appearance. It consists of a keyboard of about fifty keys which are operated by depressing them with the fingertips, and a printing mechanism that types one character at a time onto paper which is fed over a rotating platen. Nearly all teletypewriters in the Octopus network are Model 33 Teletypes* — see Fig. 1 — and the discussion here will refer specifically to them. There are a few terminals of other kinds, particularly Models 35 or 37 Teletypes.

A teletypewriter differs from a typewriter in two respects. Pressing a key causes a timed sequence of coded bits to be sent over a twisted wire pair, and printing results when a coded bit sequence is received over another wire pair. The two wire pairs connect the teletypewriter to a PDP-8 concentrator (**Tentacle**) of the teletypewriter subnetwork. This concentrator collects typed characters from, and distributes characters for printing to, 128 teletypewriters. That is, printing of a typed character occurs only because it is **echoed** back to the teletypewriter by the Tentacle.

The Model 33 Teletype has a three-position switch by which the user can select the mode of operation just described (**Line** operation), can disconnect the terminal from the network and cause it to behave like a typewriter with a direct connection between keys and printing mechanism (**Local**), or can disable the device entirely (**Off**). A light to the right of the keyboard is lit when the switch is in the Line position.

Maximum typing and printing rate is ten characters per second. Teletype paper is mounted at the rear of the machine in a large roll and is friction-fed over the platen. A printed line consists of 72 characters spaced ten per inch horizontally. Lines are spaced six per inch vertically.

1.2 CHARACTER CODES

The coded sequence that is transmitted to represent a character adheres to the ASCII standard described in LTSS-Ø in the section entitled “Character Set.” (Throughout this chapter all character codes are given in octal.) During transmission the low-order (rightmost) bit is sent first, followed by the seven coding bits; an eighth bit is included for an even parity check. The PDP-8 Tentacle can detect **parity failure** in the characters it receives. On the other hand, most Teletypes ignore the parity bit of received characters.

*Teletype is a registered trademark of the Teletype Corporation.

Terminals acquired in the future will in almost all cases have facility for the full 128-character ASCII set shown in Table 1 (as do Model 37 Teletypes), or even for an extended set of 256 characters (e.g., KIDS terminals). The keyboards of such terminals will, in the normal (unshifted) mode, generate lower-case alphabetic characters, rather than upper-case alphabetic characters. This is a significant difference from the vast majority of present terminals (Models 33 and 35 Teletypes), which generate upper-case alphabetic codes in unshifted mode and which in fact are not able either to generate or to print lower-case alphabetic characters (and the few other characters in the code range 140 to 176).

Therefore, in the interest of long-term compatibility, when a Tentacle receives an upper-case alphabetic character from a Model 33 or 35 Teletype, it immediately changes it to the corresponding lower-case character. This gives the Octopus network the illusion that all terminals normally generate lower-case alphabets; no alphabetic character typed on a Model 33 or 35 Teletype will be interpreted by the network as being upper-case. It should be remembered that those computers that store characters internally as 6-bit bytes store the lower-case (normally typed) alphabets as single bytes. No alteration is made in characters sent from a Tentacle to Models 33 or 35 Teletypes; a peculiarity of the printing mechanism causes the same alphabetic character (upper-case) to be printed whether the received code is upper- or lower-case. However, a paper tape attached to the Teletype will be punched with the code actually received (probably lower-case).

Model 33 and 35 Teletypes have a few other minor departures from the ASCII code illustrated in Table 1: codes octal 136 and 137 are printed as ↑ (up arrow) and ← (left arrow) rather than as ^ (carat) and _ (underline). Also, some control characters are identified by non-ASCII mnemonics.

1.3 INPUT AND ECHO

1.3.1 Keyboard

The Model 33 Teletype keyboard is shown in Fig. 2. Forty-two of the keys generate a graphic character, as indicated on the lower part of the key cap. (Letters are to be regarded as lower-case.) In addition, 21 of these keys generate a different graphic character when either

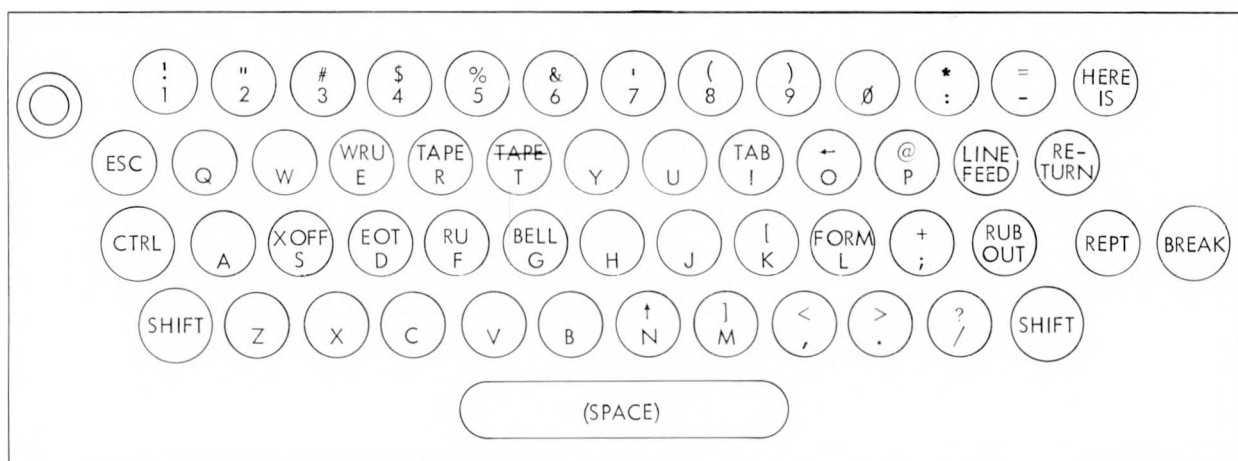


Fig. 2. The Teletype keyboard.

(or both) of the **shift** keys are held down. The **space bar** generates the space. The remaining 31 graphics (including the upper-case letters) are not available on the Model 33.

Some **control characters** can be generated by depressing an appropriate single key, viz: linefeed (LF), carriage return (CR), escape (ESC), delete or rub out (DEL), and null or break (NUL). The **break** key is unique in that it generates a sequence of null characters so long as it is depressed; it may also generate one other character at the time it is released. Any control character except rub out (DEL) may be generated by pressing a letter key, and perhaps a shift key, while the **control** key is held down (see Table 1). **This operation is indicated throughout this chapter by a construction of the form: (CTRL-X).**

The **repeat** (REPT) key can be used to cause rapid repeated generation (ten characters per second) of any single character. Simply depress the repeat key and the key or keys generating the desired character simultaneously.

The **Here Is** key generates no character of its own, but activates the **answer-back** mechanism inside the teletypewriter. This mechanism consists of a small drum onto which a sequence of up to 20 characters can be recorded. When the mechanism is activated, this sequence is sent once at ten characters per second.

A so-called **red button** has been added to most Teletypes; pressing it alters the codes generated at the keyboard. Since this button no longer serves any purpose in regard to network communication, it is not discussed further. Using it will usually give rise to difficulty.

1.3.2 Messages

Tentacles deal individually with the teletypewriters to which they are attached. Activity at one terminal does not influence the other terminals. The only possible exception is that the resources of the Tentacle may become overloaded. Therefore, the discussion may be limited to the relationship between a single teletypewriter and the Tentacle to which it is attached.

Most input characters received by the Tentacle from the keyboard are assembled verbatim into an **input message**; exceptions are noted below. When the input message is complete, the appropriate Octopus heading (discussed in section 1.6.2) is attached and the message is forwarded to a worker computer (or the Elephant computer). Input messages are limited to 84 characters each. The characters of the input message are also echoed (sent back) to the terminal from which they came. Thus, the user has a visible record of what he has typed. Echoing is verbatim, except as noted below and in Table 1.

1.3.3 Logging In

A Tentacle regards a teletypewriter as being either **logged out** or **logged in** to a particular worker computer (or the Elephant computer). The Tentacle expects the first character received from a logged-out teletypewriter to be the (lower-case) letter designator of the computer into which the user of the teletypewriter wishes to be logged. If it receives such a character, an input message is begun with the characters "ID," the letter designator that was typed, and a space; these four characters are echoed verbatim. This is the only instance in which an input graphic (non-control) character is not assembled into an input message and echoed verbatim. The message thus begun is called an **ID message** (and will have the Id bit set in its heading), and the teletypewriter is regarded as being logged in to the designated computer.

If a character other than a valid letter designator is received from a logged-out teletypewriter, the teletypewriter remains logged out and no input message is begun. Most such characters are responded to with the following echoed message: @BYE, linefeed, carriage return, linefeed.

Four control characters are exceptions. CAN, EM, and DEL (rub out) are ignored, but may cause echoing of a rub out. (“Printing” of a rub out results in visible and audible operation of the printing mechanism, but with no net effect. This is called **non-space** operation.) NUL (break) causes the teletypewriter keyboard to be disabled for 4 to 5 seconds, after which it behaves as though DEL or a bad-parity character has been received.

A user can quickly and easily determine whether a teletypewriter is logged in or out, because of the unique way in which input from a logged-out teletypewriter is treated.

1.3.4 End of Input Message

The end of an input message is signalled by one of three input characters: **linefeed** (LF or CTRL-J; 012), **end of transmission** (EOT or CTRL-D; 004), or **end of transmission block** (ETB or CTRL-W; 027). These are all assembled verbatim into the message which they end; however, in the case of LF or EOT, an ETB (027) is also assembled into the message in the succeeding position. Thus all input messages normally end with a standard character (ETB), but the actual end character typed by the user is not lost. (However, it may be discarded at a later point by the operating system of a worker computer.) If an EOT is the first (as well as the last) character of a message, a following ETB is not assembled; this creates a unique message which signifies a desire to log out (as discussed in section 1.3.9).

Each of the three end characters has a distinctive echo. Linefeed (LF) is echoed as a carriage return followed by a linefeed. End of transmission (EOT) is echoed as a rub out. End of transmission block (ETB) is echoed as a space. Thus, by choice of end character, the user can cause succeeding printing to occur on the next line or on the same line (with or without an intervening space).

If an 84th character is input to a message, the message is regarded as complete. No terminating ETB is assembled (unless, of course, the 84th character is itself an ETB.)

1.3.5 Forwarding

A completed (but not necessarily fully echoed) message is **forwarded** through the teletypewriter subnetwork to the computer into which the teletypewriter is logged. (See the section entitled “Message Network” in LTSS-0.) Forwarding is done immediately, *unless* the echoing of the *preceding* input message is incomplete, in which case forwarding is delayed until that echoing is complete. (Echo of input can be delayed, as discussed in section 1.4.1.) So long as an input message remains unforwarded, the Tentacle will refuse input characters that attempt to begin a new message. That is, for a given teletypewriter, the Tentacle will keep track of no more than two input messages; if there are two, the first is complete and forwarded but incompletely echoed (perhaps not echoed at all), and the second is neither echoed nor forwarded, but may be complete.

When the forwarded message reaches its destination (the computer into which the teletypewriter is logged), it is acted upon according to rules defined by the operating system of that computer. In the case of an ID message, the operating system will normally make a record of its own that the teletypewriter is logged in to that computer.

A forwarded input message may not reach its intended destination because a temporary or extended failure has blocked the possible paths through the network. In this case, the message is normally returned to the Tentacle with the Error bit set in the heading (see section 1.6.2; see also the section entitled “Headings” in LTSS-0). The Tentacle discards the message and does the following: (1) If the message is an ID message, the teletypewriter is logged out (since the

Table 1. Teletype codes and 7-bit ASCII character set

ASCII code	Character ^a	6-bit code	Model 33 keyboard	Echo ^{c,d}	Output ^{c,d}	ASCII code	Character ^a	6-bit code	Model 33 keyboard	Echo ^{c,d}	Output ^{c,d}
000	NUL (BREAK)	400200	Break; CTRL-Shift-P	@#*%!	(pause)	100	@	400300	Shift-P		
001	SOH	400201	CTRL-A	DEL	DEL	101	A	400341	__b	__b	__b
002	STX	400202	CTRL-B	DEL	DEL	102	B	400342	__b	__b	__b
003	ETX	400203	CTRL-C	DEL	DEL	103	C	400343	__b	__b	__b
004	EOT	400204	CTRL-D	DEL		104	D	400344	__b	__b	__b
005	ENQ (WRU)	400205	CTRL-E	%	%	105	E	400345	__b	__b	__b
006	ACK (RU)	400206	CTRL-F	DEL	DEL	106	F	400346	__b	__b	__b
007	BEL	400207	CTRL-G			107	G	400347	__b	__b	__b
010	BS	400210	CTRL-H			110	H	400350	__b	__b	__b
011	HT (TAB)	400211	CTRL-I	(space)	(space)	111	I	400351	__b	__b	__b
012	LF (LINEFEED)	400212	Linefeed	LF, CR		112	J	400352	__b	__b	__b
013	VT	400213	CTRL-K	LF	LF	113	K	400353	__b	__b	__b
014	FF (FORM)	400214	CTRL-L			114	L	400354	__b	__b	__b
015	CR (RETURN)	400215	Return			115	M	400355	__b	__b	__b
016	SO	400216	CTRL-N			116	N	400356	__b	__b	__b
017	SI	400217	CTRL-O			117	O	400357	__b	__b	__b
020	DLE	400220	CTRL-P	DEL	DEL	120	P	400360	__b	__b	__b
021	DC1 (XON)	400221	CTRL-Q			121	Q	400361	__b	__b	__b
022	DC2 (TAPE)	400222	CTRL-R			122	R	400362	__b	__b	__b
023	DC3 (XOFF)	400223	CTRL-S			123	S	400363	__b	__b	__b
024	DC4 (TAPE)	400224	CTRL-T			124	T	400364	__b	__b	__b
025	NAK	400225	CTRL-U	DEL	DEL	125	U	400365	__b	__b	__b
026	SYN	400226	CTRL-V	DEL	DEL	126	V	400366	__b	__b	__b
027	ETB	400227	CTRL-W	(space)	(pause)	127	W	400367	__b	__b	__b
030	CAN	400230	CTRL-X	@	(pause)	130	X	400370	__b	__b	__b
031	EM	400231	CTRL-Y	CR,////,LF,CR		131	Y	400371	__b	__b	__b
032	SUB	400232	CTRL-Z	%	DEL	132	Z	400372	__b	__b	__b
033	ESC	400233	ESC			133	[	73	Shift-K		
034	FS	400234	CTRL-Shift-L			134	/	74	Shift-L		
035	GS	400235	CTRL-Shift-M			135	}	75	Shift-M		
036	RS	400236	CTRL-Shift-N			136	^(+)	76	Shift-N		
037	US	400237	CTRL-Shift-O			137	_ (←)	77	Shift-O		
040	(space)	00	Space bar			140	\	400340	__b	__b	__b
041	!	01	Shift-1			141	a	41	A		
042		02	Shift-2			142	b	42	B		
043	#	03	Shift-3			143	c	43	C		
044	\$	04	Shift-4			144	d	44	D		
045	%	05	Shift-5			145	e	45	E		
046	&	06	Shift-6			146	f	46	F		
047	'	07	Shift-7			147	g	47	G		
050	(	10	Shift-8			150	h	50	H		
						151	i	51	I		

051	)	11	Shift-9	152	j	52	J			
052	*	12	Shift-:	153	k	53	K			
053	+	13	Shift-;	154	l	54	L			
054	,	14	,	155	m	55	M			
055	-	15	-	156	n	56	N			
056	.	16	.	157	o	57	O			
057	/	17	/	160	p	60	P			
060	Ø	20	Ø	161	q	61	Q			
061	1	21	1	162	r	62	R			
062	2	22	2	163	s	63	S			
063	3	23	3	164	t	64	T			
064	4	24	4	165	u	65	U			
065	5	25	5	166	v	66	V			
066	6	26	6	167	w	67	W			
067	7	27	7	170	x	70	X			
070	8	30	8	171	y	71	Y			
071	9	31	9	172	z	72	Z			
072	:	32	:	173	{	400373	__b	__b	__b	__b
073	;	33	;	174		400374	__b	__b	__b	__b
074	<	34	Shift-,	175	}	400375	__b	__b	__b	__b
075	=	35	Shift--	176	~	400376	__b	__b	__b	__b
076	>	36	Shift-.	177	DEL(RUBOUT)	400371	Rub Out			
077	?	37	Shift-/							

^aThe alternate graphic or mnemonic appearing on the Model 33 Teletype is given in parentheses.

^bNot available on Model 33 Teletype.

^cNo entry means verbatim.

^dN.B.: because of peculiarities of the Model 33 printer, the *printing* of a character may not correspond either to its echo or to its output. See text.

computer involved presumably did not learn of the log-in). (2) Any unforwarded input is cancelled. (Input message cancelling is discussed below.) (3) A message is echoed to the teletypewriter of the form: @SORRY, carriage return, linefeed (if the teletypewriter is still logged in), or @BYE, line feed, carriage return, linefeed (if it is logged out). Thus are you informed that your input has been discarded.

1.3.6 Input Cancellation

The entire input message currently being typed (or a complete but unforwarded input message) is cancelled when **end of medium** (EM or CTRL-Y; 031) is input. The cancellation is indicated by echo of carriage return, pause, five reverse slants (symbolizing strike-out of the message), carriage return, linefeed. Any characters of the cancelled message not already echoed are never echoed. However, if no part of the cancelled message has been echoed (or if there is no message to be cancelled), the message cancel produces at most the “printing” of a rub out, leaving the printing as though there had never been a message. If an ID message is cancelled, the teletypewriter is logged out.

Any (complete or incomplete) unforwarded input message is automatically cancelled under the following conditions: (1) A previous message is returned with the Error bit set (as discussed above and in section 1.6.2). (2) the teletypewriter is logged out at the time echoing begins (unusual but possible). (3) No new input character has been added to the message for 10 to 20 minutes; this prevents “forgotten input” from clogging the Tentacle buffers.

The character most recently assembled into an input message is cancelled by input of the **cancel** (CAN or CTRL-X; 030) character. Any number of characters in a single message may thus be cancelled by working back from the most recent one. However, an end character (LF, EOT, ETB, or an 84th character) may not be cancelled; that is, single characters may not be cancelled from a completed message (although the entire message may be cancelled if the message has not yet been forwarded).

If the cancelled character has already been echoed, then the cancel character itself is echoed as an @ (at); this is intended to suggest a blotting out of the character. (This use of @ must be distinguished by context from the normal use.) If the cancelled character has not been echoed, then the cancel character itself is not echoed, and the printing is as though the cancelled character had never been input. If all characters in the input message are already cancelled, then character cancel is treated as message cancel. If there is no input message, character cancel is echoed as a rub out.

1.3.7 Miscellaneous Input

Null (NUL, Break, or CTRL-shift-P; 000) is intended for use when you suspect some difficulty in the system or in your program. The Tentacle treats an input break first of all as a message cancel. It then assembles a complete input **break message** consisting of a single NUL (000) followed by an ETB (027). This message is echoed as a **mild oath** (@#*%!), carriage return, linefeed. Further input is ignored until the oath is printed; this should give you time to lift your finger from the Break key and thus input exactly one (rather than an unpredictable number) of nulls. There is one and only one oath echoed for each break message forwarded.

Delete (DEL or rub out; 177) is at most “printed” verbatim (i.e., it causes non-space operation); it is otherwise completely ignored. It is a logical nothing. One reason for thus ignoring

it is that it can be generated (with correct parity) by a single noise bit on a quiescent Teletype line; a second reason has to do with conventions in regard to preparation of paper tape.

1.3.8 Miscellaneous Echo

The only characters that receive special treatment when they are input from a logged-in teletypewriter (LF, EOT, ETB, EM, CAN, NUL, DEL) have all been discussed, together with their distinctive echoes. Several more characters are assembled into an input message verbatim but have distinctive echoes.

Horizontal tab (HT or CTRL-I; Ø11) is echoed as a space (as though there were a tab stop at every point on the line). Similarly, **vertical tab** (VT or CTRL-K; Ø13) is echoed as a linefeed (as though there were a tab stop on every line); thus VT can be used to feed the line without simultaneously ending the message (as the linefeed character itself does). **Enquiry** (ENQ or CTRL-E; Ø05) is echoed as a % (percent). This character is thus made “visible” because it is used to communicate with operating systems (as noted below). All communication controls other than EOT, ENQ, and ETB (already discussed), namely, SOH (CTRL-A), STX (CTRL-B), ETX (CTRL-C), ACK (CTRL-F), DLE (CTRL-P), NAK (CTRL-U), and SYN (CTRL-V) are echoed as rub outs; this should not even be noticed by the user.

Substitute (SUB or CTRL-Z; Ø32) is used in connection with the **echo-suppress** feature. A teletypewriter to which echo characters are being sent is recognized by the Tentacle as being in one of two echo modes: normal and suppress. In echo-suppress mode, those characters which are normally echoed verbatim, as well as HT, VT, and the communication controls listed in the last paragraph, are echoed as % (percent). (This use of % must be distinguished by context from the normal use.) Thus the echo-suppress mode provides a way to input characters without leaving a written record of what they are. Only those characters that receive special treatment on input (LF, EOT, ETB, EM, CAN, NUL, DEL) are unaffected by the suppress feature.

Echo-suppress mode is entered by inputting SUB (CTRL-Z). This character is assembled into the input message verbatim but is echoed as a %. Echo-suppress mode is left by typing LF, EOT, ETB, or EM, that is, by ending the message normally or by cancelling it. Thus, once echo-suppress mode is entered, it applies to the balance of the current message. Echo of a new input message begins in normal mode, unless the previous message was 84 characters long and ended without an end character while in suppress mode. Character cancel does not affect the echo mode (even if it cancels a SUB), unless it results in a message cancel.

1.3.9 Logging Out

An input message consisting solely of an EOT (CTRL-D) is universally understood in the Octopus network as a request by a user to log out the terminal he is using. However, the Tentacle normally takes no direct action in regard to such a message. The message is forwarded in the usual fashion and the destination computer returns an output message with the Bye bit set in the heading; this causes the Tentacle to log out the teletypewriter (as discussed in section 1.6.2). This roundabout scheme prevents awkward situations in which output arrives after the user has requested to be logged out.

However, there is the possibility that the computer into which a teletypewriter is logged has “gone down” or otherwise become inaccessible. Then the desired output message indicating log-out is never sent. Therefore, if a teletypewriter generates two EOT-only messages with no output messages having been printed (or at least received to be printed) in the interim, the Tentacle

will discard the second message, immediately log the teletypewriter out, and echo the message: @BYE, line feed, carriage return, linefeed. Thus a teletypewriter (but *not* the associated user program in a worker computer) can be “freed” by a few EOT inputs in succession. Note that when @SORRY is printed (because unforwardable input was returned) it is classed as an echo, not as output; therefore it does not prevent a second EOT from effecting an immediate log-out.

1.4 OUTPUT

1.4.1 Relation to Echo

A Tentacle will accept messages to be output to a teletypewriter from the computer into which the teletypewriter is logged. Such messages are limited to 150 characters each. Most characters are sent to the teletypewriter verbatim; exceptions are noted below.

Since the output characters must share the printing mechanism with echo characters, an algorithm is required for interlacing the two streams of characters. This algorithm is as follows: Once echoing has begun, it continues until all input is complete, forwarded, and echoed, that is, until there is nothing to do except (perhaps) output. Even then, output is not permitted, if the last input message ended simply because it reached 84 characters. That is, for output to be permitted, the message must have been cancelled or have ended with an LF, EOT, ETB, or NUL. In short, the user indicates his willingness to receive output by ending his input normally.

Once output has begun, it continues until one of three particular control characters is encountered in the output stream: EOT (004), ETB (027), or SUB (032), or until a NUL (break) is *input*; either of these events is said to open an **echo window**. Output (if there is any more) will resume when the echoing is complete, as described above; this may happen immediately if there is nothing to echo. If new input starts to arrive while output is going on, therefore, the echo will be delayed until a suitable character (EOT, ETB, or SUB) in the output is encountered, unless the user immediately forces open an echo window by means of the break. If the user finds delayed echoing objectionable, he can avoid it by not typing while output is in progress. EOT, ETB, and SUB each cause a pause of 0.1 second before the echo window is opened. An echo window is opened automatically if there is something to echo and there has been neither input nor echo for 10 to 20 minutes. When an echo window is forced open this way or by a break, while output is in progress, the echo is preceded by carriage return and linefeed.

An output message is deemed to have ended, and the rest of it is discarded and not printed, when one of the following control characters is encountered: EOT (004), ETB (027), or EM (031). Thus, the output may indicate that an echo window is to be opened (with SUB), that the message has ended (with EM), or both simultaneously (with EOT or ETB). If striking a key while no printing is in progress does not give rise to an immediate echo response, but makes a “dead” sound, it is because output has ended without opening an echo window (either by encountering an EM or simply by reaching the end of the message). In such a situation, only the rub out printed in response to an input DEL (and, in certain circumstances, EM or CAN) will take place immediately; of course a NUL (break) can force open an echo window. It is intended that messages which end without opening an echo window be sent only if another message is to follow immediately.

1.4.2 Miscellaneous Output

Since characters are stored in messages in 8-bit bytes, it is possible that an output message contains characters outside the 128-character ASCII set (i.e., characters with a high-order bit of 1). All these characters are printed as % (percent). Also, several control characters are not output verbatim, as follows: NUL (000) and CAN (030), as well as EOT (004), ETB (027), and SUB (032), are each “output” as a pause of 0.1 second. EM (031) is not output at all. HT (011) and VT (013) are output as they are echoed, namely as space and linefeed, respectively. The same is true of the communication controls other than EOT and ETB (already mentioned) and ENQ; that is, SOH (001), STX (002), ETX (003), ACK (006), DLE (020), NAK (025), and SYN (026) are output as rub outs. You will probably not notice them. Note that ENQ (WRU or CTRL-E; 005) is output, but not echoed, verbatim. Note also that LF (linefeed; 012) is output verbatim.

1.4.3 Printer

Characters received at the Model 33 Teletype (whether output, echo, or otherwise) cause the printing of a single character. “Printing” is used here in a generalized sense, since it does not always consist of placing a visible mark on the paper. The 64 graphic characters with codes 040 to 137 are printed verbatim and the carriage spaced one to the right (unless it has already reached the extreme right). The space character (040) is unique in that its printed form is entirely blank. The 28 graphic characters with codes 140 to 173 are printed as if they were the corresponding characters with octal codes lower by 040₈; that is, lower-case letters (141 to 172) are printed as upper-case letters, open single quote (140) is printed as @, and left brace (173) is printed as left bracket. The remaining 3 graphics (174 to 176) cause non-space operation.

Most control characters (000 to 037 and rub out or DEL, 177) also cause non-space operation. Exceptions are linefeed (LF, 012), which feeds the paper forward one line; carriage return (CR, 015), which returns the carriage to the extreme left of the current line; bell (BEL, 007), which rings a gong; and enquiry (ENQ, or WRU, 005), which activates the answer-back mechanism. (Note that the answer back can be so activated only on output, since ENQ is not echoed verbatim; the answer back can be activated from the keyboard with the Here Is key.)

An important point is that the effect of the carriage return may require an additional 0.1 second to complete; therefore, on output (or echo, if it is to be delayed) carriage return should always be followed by a character that does not actually print (such as linefeed).

Some Teletypes are equipped with paper-tape equipment. On these Teletypes, the four device controls are effective as follows: DC1 (XON or CTRL-Q; 021) turns the reader on, and DC3 (XOFF or CTRL-S; 023) turns it off. DC2 (TAPE or CTRL-R; 022) turns the punch on, and DC4 (TAPE or CTRL-T; 024) turns it off.

1.4.4 Other Output Action

If an output message received by the Tentacle has the Bye bit set in its heading, the teletypewriter is logged out before the associated message is completely printed. This bit is set by the operating system of the computer into which the teletypewriter is logged as a response to an EOT-only input message or other appropriate condition (such as an ID message of invalid format).

A worker or Elephant computer operating system may set the Id bit in an output message; this will cause the teletypewriter to become logged in to that computer, provided that it is not

already logged in. This feature is used only in connection with teletypewriters reserved for computer operators.

1.5 OTHER PRINTING

1.5.1 Timer

Most Octopus Teletypes are provided with a timer. If no printing occurs for a period of a minute or two, part of the internal mechanism is shut down to prevent unnecessary wear and tear. If you desire to type on a “run down” Teletype, you must first **warm up** the Teletype by pressing the back-lighted button to the right of the keyboard. The back-light goes out when the Teletype “runs down.”

The Teletype is also warmed up by receipt of an output character. However, this warm-up is effective only after a delay. Therefore, if no character has been sent to a teletypewriter for a period of 30 to 40 seconds, the Tentacle will precede any new printing with a NUL (000) and a pause of 0.7 second.

1.5.2 Trouble

Various abnormal conditions cause three bells (007) to be immediately sent to the teletypewriter in quick succession. The “printing” of these bells takes precedence over any output or echo that may be in progress. You are advised to stop typing when you hear this **trouble signal** and wait until all printing has ceased, so that you can determine exactly what the situation may be. Conditions giving rise to the trouble signal are as follows:

- An input character is received at the Tentacle with bad (odd) parity.
- Because of unusually high loading of the Tentacle, an input character is missed (very rare).
- Because there has been no input activity for 10 to 20 minutes, a message is cancelled and/or an echo window is opened.
- The Tentacle has run out of buffer space; in this case, the current input message is also cancelled (rare).
- Because of limited space for keeping the necessary records and because of delays in echoing, the @ indicating character cancel cannot be printed (unusual but possible).
- An attempt is made to begin a new input message when the previous message is unforwarded (and therefore the message second previous is incompletely echoed).
- An input message is returned as unforwardable.
- Echo begins after the teletypewriter is logged out.
- Input other than a valid letter designator is received when the teletypewriter is logged out.
- The teletypewriter is logged out immediately upon receipt of a second EOT.
- A broadcast is about to begin (as described immediately below).

1.5.3 Broadcast

Worker or Elephant computer operating systems can **broadcast** messages of general interest to large numbers of teletypewriters at once. These messages have priority over all other printing that may be in progress.

If the Tentacle computer must be reset (as described in section 1.6.3), the message @BYE, linefeed, carriage return, linefeed is broadcast to all its teletypewriters, and they are logged out.

1.6 SYSTEM PROTOCOL

1.6.1 Teletypewriter Identification

Teletypewriters are identified by a 3-digit octal integer, 000 to 777. (All teletypewriter, machine, and device numbers are given in octal.) The first two bits of this 9-bit pattern identify the Tentacle to which the teletypewriter is attached; that is, teletypewriters 000 to 177 are attached to one Tentacle, 200 to 377 to another, 400 to 577 to a third, and 600 to 777 to a fourth. The first Tentacle (with teletypewriters 000 to 177) does not exist at the present time. The last seven bits of the teletypewriter number distinguish different terminals on the same Tentacle.

The general user should probably now skip ahead to section 1.7, since the remainder of this section is directed to system programmers.

1.6.2 Headings

All input and output messages are preceded by the standard 48-bit Octopus heading (see the section entitled "Headings" in LTSS-0). Tentacles will relay messages directed to any computer in the network, provided the message text does not exceed 1212 bits (151½ characters). As with all messages, forwarding is tried both by the most direct route and, if that fails, through the Elephant computer, from which the message may travel through the file-transport network.

Messages originated in a Tentacle, including teletypewriter input messages, are always directed to a worker or the Elephant Computer, device 0. The source machine number is 40, 41, 42, or 43 (indicating the Tentacle and range of teletypewriter numbers), device 000 through 177 (indicating the low-order seven bits of the teletypewriter number). Output messages are the same, except that source and destination are reversed; the Tentacle ignores the device field of the source. Other bits in the heading are used as described below.

The Id bit on input indicates an ID message. On output, it will effect "internal" log-in of a logged-out teletypewriter.

The Bye bit is unused for (non-error) input. On output, it will effect log-out.

The Error bit on input means that an output message has been rejected and is being returned for one of the following two reasons: (1) The source computer is neither a worker nor the Elephant computer, or the teletypewriter is not logged in to the source computer (unless the Id bit is set and the teletypewriter is logged out). In this case, the Bye bit is also set. (2) The output arrived while new output was inhibited (as described below). In this case control bit 6 (the Early bit) is also set. On output, the Error bit will cause echo of @SORRY or @BYE (as already described). A message that a Tentacle is attempting to relay is of course returned with the Error bit set if some difficulty prevents forwarding.

The Binary bit is 0 on input and is ignored on output (although it should not be set, since the Tentacle of course assumes that the text is ASCII).

The Type field (4 bits) is 0 on input and is ignored on output (although it should be 0). Also, control bits 1 through 4 are 0 on input and are ignored on output.

Control bit 5, the No Text bit, when set, indicates that the message has no text. On input, such a message is used as described below in the discussion of the Toggle bit. On output, such

a message (if not received early) is treated as if instantly printed and neither opens nor closes an echo window; it can be used to set the Toggle state (see below).

Control bit 6, the Early bit, is $\emptyset$ on input unless used as described above in connection with the Error bit. It is ignored on output.

Control bit 7, the Toggle bit, is used to regulate the rate of output. A Tentacle has limited buffer capacity and could easily be overwhelmed by unrestricted output from even a single worker-computer program. Therefore, a worker or Elephant computer operating system should, after sending an output message to a teletypewriter, inhibit (hold back) any further output for that teletypewriter until a positive enable (go-ahead) is received from the Tentacle. If the Tentacle receives further output before it has sent the enable, it rejects the output and returns it with the Error and Early bits set.

The output enable does not consist merely of a single special message sent at the time the Tentacle is ready, since if that message were somehow lost because of a temporary failure, output would never resume. Instead, the following, more complex, scheme is used: Every input and output message contains a Toggle bit. In addition, the teletypewriter has a one-bit Toggle state that is remembered both by the Tentacle and by the computer into which the teletypewriter is logged. The worker (or Elephant) computer operating system should send the value of the Toggle state in the Toggle bit of each output message. This should be the same as the Toggle state as it is recorded in the Tentacle, but (in order to straighten records out if confusion arises) the Tentacle always sets the state to the value of the received bit, provided that the message was not early. As explained above, at the time the Tentacle receives an output message, the worker (or Elephant) computer involved should regard further output to the teletypewriter as inhibited.

When the Tentacle is ready for further output, it changes the Toggle state and sends a No Text message to the worker or Elephant computer. The Toggle bit of this message contains the current (changed) value of the Toggle state. Also, the Toggle bits of all input messages contain the current value of the Toggle state; thus, if a message is lost, the next message will convey the fact that the Toggle state has changed. When the worker (or Elephant) computer sees that the Toggle state has changed, it corrects its record of the state and reenables (i.e., discontinues inhibiting) output. If the worker (or Elephant) computer gets impatient and suspects that some error has occurred in its records, it can send a No Text output message; this message will not affect the teletypewriter at all but will either bring the Tentacle records into conformity with those of the worker or will be returned with the Error and Early bits set, indicating that the worker computer should be more patient. The Toggle state is $\emptyset$ at log-in.

The Tentacle reenables output and changes the Toggle state at some time when not less than 1 nor more than 23 output characters remain to be printed. (However, if an unnecessary number of "filler" bits follow a terminating EOT, ETB, or EM, enable may occur only after all output characters are printed.) To find how many characters in a message remain to be printed when enable occurs, subtract from the number of characters in the message the largest number in the following list which is less than that number: 0, 16, 38, 61, 83, 106, 128.

A No Text enable message is of course not sent if the teletypewriter has been logged out. In fact, a Bye bit in the heading of an output message effects a log out just when reenable would have taken place.

The **Chain bit** in $\emptyset$ in input and is ignored (but assumed to be $\emptyset$) on output.

1.6.3 Special Messages

Messages output to device numbers 200 to 377 on a Tentacle are given special interpretation. No logged-in status is required. Exception to the above discussion of headings has to be taken. If the Error bit is set, the message is discarded. Id, Bye, Binary, Type, Control, and Chain fields are ignored. The special interpretation given depends on the device number as now summarized.

Devices 200 to 366 indicate a no-operation **test message**. The message is returned verbatim (except for interchange of source and destination fields).

Devices 367 to 371 indicate that the accompanying text is to be **broadcast**. A No Text reply from the same device is sent when the broadcasting is complete. If a previous broadcast is in progress, the message is refused and the Error and Early bits are set. The received text is automatically preceded by a carriage return and linefeed. The three device numbers distinguish the following choices:

- Device 367 — broadcast only to those teletypewriters logged in to the computer sending the broadcast.
- Device 370 — in addition, broadcast to logged-out teletypewriters.
- Device 371 — broadcast to all teletypewriters.

Devices 372 and 373 request a **dump of Tentacle core**; the former device indicates main core, and the latter, extended core. There are assumed to be 24 bits of text, the first 12 of which define an address and the second 12 define a count (with 0 being interpreted as 4K). The text of the reply repeats the address and count and follows it with the dump (which may be of arbitrary length up to 4K 12-bit words and which will “wrap around” from location octal 7777 to location 0, if necessary).

Devices 374 and 375 request a one-word **patch of Tentacle core**; the former device indicates main core, and the latter, extended core. There are assumed to be 24 bits of text, the first 12 of which define an address, and the second 12, the patch. A reply is given, repeating the address and patch.

Device 376 requests a **reset** of the Tentacle (return to initial state, all messages forgotten, teletypewriters logged out). There is no reply, except that the reply to the general @BYE broadcast is sent to the Elephant computer. A Tentacle automatically resets after a power failure or if started at location octal 7600.

Device 377 announces a **reload** of the Tentacle. The Tentacle will halt within a millisecond at its bootstrap loader (location octal 7772) waiting for the load as a single transmission of up to 4K beginning at location 0 of main core. If the proper code is loaded, a reset immediately follows.

1.6.4 Interfaces

(See “Protocol of Transmission” in LTSS-0.) Tentacles leave their Receive Permitted bits in all interfaces set almost all the time. They set their Send Requested bits when they have something to send; they then wait not less than 0.1 seconds nor more than 0.2 seconds for the transfer to take place. If the transfer does not take place successfully, they try the interface to the Elephant computer (unless that was the interface they tried the first time), at which they wait 0.1 second. If both attempts fail, they go through the standard Error bit procedure.

A load must be preceded by a suitable hardware start pulse, since the Tentacle halts at location octal 7772 when a load is requested.

1.7 WORKER OPERATION

The exact way in which teletypewriter messages are used by the worker (or the Elephant) computers is specific to each computer. The remaining parts of this chapter discuss the peculiarities of each operating system (see Table 2). Some general principles are outlined here.

Table 2. Operating systems

Manufacturer	Computer	Designators	Operating system	Section
DEC	PDP-10	P, Q	GATOR	2
CDC	6600	G, L, M	FROST	3
CDC	7600	R, S, T	FLOE	4

The operating system must translate between 8-bit ASCII and any internal representation. It must supply appropriate headings on output and keep track of the enable condition and Toggle state. It must decide which input is for the user's own program and which is directed to the system itself. The break message should at least cause it to check for possible sources of difficulty.

It should respond to ID messages by checking for a valid format. If invalid, it should return as output an appropriate comment in a message that includes the Bye bit. Otherwise, it should record that the teletypewriter is logged in together with the user's number (taken from the ID message). On receipt of the EOT-only input message, it should send an appropriate message (such as BYE) containing the Bye bit.

Normally, of course, an ID message should be received if and only if the teletypewriter is recorded as being logged out. Anomalous cases should be handled along the following general lines: If an ID message is received from a teletypewriter recorded as being logged in, the recorded status should be changed to logged out and the ID message interpreted normally. On the other hand, a non-ID message received when the teletypewriter is recorded as being logged out should be treated as would an invalid ID message. If the user who is attempting to log in is already recorded as being logged in at another terminal, he should be so informed and his attempt rejected. However, some form of test message should immediately be sent to the other terminal; if it returns in error (other than Early), records should be changed to show that the user logged out, thus permitting him to log in on his next try. These stratagems should straighten out any peculiarities arising from confused records and/or hardware failure.

Valid ID messages should adhere to the general format:

IDX user misc. level combination,

where *IDX* is the pattern "ID" followed by a letter designator and a space, as generated by the Tentacle; *user* is a six-digit decimal user number; *misc.* is various miscellaneous information (perhaps none) as required by each particular operating system; *level* is the letter mnemonic of a security level; and *combination* is a 6-character user-identity verification code, which must be typed in echo-suppress mode (see section 1.3.8).

2. GATOR (D.E.C. PDP -10) Operation

The operating system of the Elephant PDP-10 computers is called HYDRA. GATOR is a subsystem of HYDRA that schedules and runs user programs. There are two processors (P and Q), each having its own independent GATOR system.

See the Suggested Reading list for more detailed information on GATOR.

2.1 ID MESSAGES

ID messages are of the form given in section 1.7. There is no miscellaneous information. The message begins with IDP or IDQ, followed by a 6-digit decimal user number. Next is a requested operating protection level, which if omitted is assumed to be P. Then, unless the level is N, a combination must be given, immediately preceded by SUB (CTRL-Z). Invalid ID lines give rise to the following replies, each preceded by a single left arrow (←):

P (or Q) COMPUTER IS UP. This machine status response is given to an ID line containing no user number or combination.

LEVEL? An ID line includes an undefined protection-level designator.

COMBINATION? An ID line that requires a combination does not include one.

N (or U, P, A, C, S, T) IS HIGHEST LEVEL. The requested operating level exceeds the named level, which is determined from the terminal and user-protection levels.

RESOURCE EXHAUSTION. GATOR is overloaded and cannot accommodate a new process.

ON TERMINAL *nnnn*. The user attempting to log in is already logged in on terminal *nnnn*.
As this message is sent, the user is logged out from that terminal.

UNAUTHORIZED. The user attempting to log in is not authorized to do so.

A valid ID line causes output of a status message consisting of the following items:

- A left arrow (←).
- The protection level (N,U,P,A,C,S,T, or K) of the proxy, delimited by asterisks (*). The proxy is the executing process currently communicating with the teletypewriter.
- The name of the proxy, followed by a slant (/).
- The name of the procedure currently being executed by the proxy.
- The state of the proxy (in parentheses). This state may be:
 - (1) ready to run or running, indicated by "READY."
 - (2) waiting for some restart condition to occur. The state is indicated by a pattern of single letters, each signifying a restart condition. The conditions are: restart after a specified time interval (T), on receipt of an input message (I), on emptying of the output buffer (O), on logging out or ceasing to be the proxy (X), on receipt of a bell (B), on completion of a file job (F), on an alert from an LDS-1 display terminal (D), on completion of a privileged operation (P), and/or on completion of other miscellaneous activities (M).
 - (3) Error, indicated by "E-" followed by a mnemonic for the error condition, as follows:
 - APAR, address parity error
 - NEXM, non-existent memory
 - DPAR, data parity error

MEMP, memory-protection violation
 PDOV, push-down overflow
 FLOV, floating overflow
 AROV, arithmetic overflow
 ILOP, illegal operation
 LREQ, self-interrupted request
 ADBK, console address break
 BKPT, breakpoint
 ISOV, interrupt-stack overflow
 TIMO, time-out
 STOP, stopped by debugging routine.

In the case of multiple errors, the one highest on the above list is given.

- (4) Protected, indicated by "PROTECT." This means that the proxy is at a level higher than the level requested by the user and is therefore cut off from teletypewriter communication.

An example of a status message is the following:

←*P* W/XCTR (IX),

this means the proxy W at level P is executing the procedure XCTR and is currently waiting either for new input or for a log out.

2.2 SPECIAL INPUT

All input from a logged-in teletypewriter is sent on as input to the proxy, with the following exceptions:

A break message (a message beginning with the NUL character) is ignored, except that various tests are made to assure that records are in order regarding teletypewriter communication.

A bell message (a message beginning with the BEL character) causes setting of the bell alarm associated with the proxy. If the proxy is waiting for a bell, it will restart.

A message beginning with the ENQ (CTRL-E; 005) character has two forms: If the ENQ is followed by a name made up of non-blank graphic characters, a process of that name becomes the proxy; if there is no such process, one is created. A status message for the new proxy is printed. If the ENQ is not followed by a name, the proxy is unchanged and the status of the current proxy is printed.

A bye message beginning with EOT (CTRL-D; 004) causes the teletypewriter to be logged out.

2.3 NORMAL INPUT AND OUTPUT

Except as noted above, all input is put into the proxy's input buffer in 7- or 8-bit ASCII as specified by a control word set by the proxy. What the proxy does with this input (as well as its reaction to the bell alarm) depends on the procedure the proxy is executing.

A newly-created proxy is executing a procedure called the **executor**(XCTR). The executor waits for input. When it receives a message it interprets it as beginning with an Elephant chain name. It loads and transfers control to the procedure contained in the named file. If the chain

name does not begin with a point (.), it is assumed to name a public procedure (either resident or in the public directory). If the message contains non-blank characters following the chain name, these are passed on to the loaded procedure as its first input message.

When the loaded procedure makes an exit call, control returns to the executor, which then waits for a new chain name. If the teletypewriter is logged out or if another process becomes the proxy while the executor is waiting for input, it destroys itself, since it has nothing useful to do.

If the executor cannot load the procedure indicated by a chain name, it will output an error message from the Elephant filing system.

Whenever the executor enters the state in which it is waiting for a new chain name to be input, it outputs a diamond-shaped pattern: ◇. This and all other output generated by the proxy is sent to the logged-in teletypewriter.

2.4 SPECIAL OUTPUT:

In addition to output from the proxy, status messages, and responses to invalid ID lines, the following messages are sent by GATOR. Each is preceded by a single left arrow (←).

INPUT TOO SOON. A message intended for the proxy was rejected because the input buffer was not empty.

INADEQUATE INPUT BUFFER. An input message intended for the proxy was rejected because the buffer was too short or otherwise could not accommodate the message.

OUTPUT MESSAGE LOST. An output message was returned to GATOR as undeliverable (presumably because of hardware malfunction).

DEFECTIVE OUTPUT BUFFER. Output requested by the proxy could not be done because the buffer descriptor contained inconsistent information.

CONTROL OP NOT DONE. The action requested with a bye or ENQ message was not performed because of conflict with other such requests.

BYE. The user is logged out. This is the response to a bye message.

3. FROST (CDC 6600) Operation

3.1 CHARACTER CODES

The FROST system represents characters by the 6-bit ASCII scheme described in LTSS-0. To reiterate, an 8-bit ASCII character is converted to this representation by the following steps (all character codes in octal):

- The 8-bit code for a lower-case letter is replaced by the code for the corresponding upper-case letter and vice versa.
- If the character code is now 100 or is outside the range 40 to 137, the 6-bit representation is in terms of 3 bytes (called a **trio**) obtained by adding 400200 to the code.
- Otherwise, the 6-bit representation is the single byte obtained by subtracting 40 from the code (the normally typed, lower-case letters fall into this category).

Thus, the space is represented by 00, the digits by 20 through 31, the lower-case letters by 41 through 72, the upper-case letters by 400341 through 400372, and at (@) by 400300.

In converting from the 6-bit representation, the process is reversed as follows:

- If a 6-bit byte is not 40, 40 is added to it; if it is 40, the next two bytes are also collected and 400200 is subtracted from the three bytes. Thus, certain 8-bit codes can be derived either from a 3-byte or a 1-byte 6-bit code; e.g., 20 and 400260 both are converted to 060, the code for the digit zero.
- The codes for the upper- and lower-case letters are interchanged.
- The trio 407777 is a special case and represents the two characters carriage return (CR, 015) and linefeed (LF, 012) in that order.

FROST expects messages generated by programs running under it to be in the 6-bit code. It converts them to ASCII before transmitting them to a Tentacle. Conversely, all messages received from a Tentacle are converted to the 6-bit code before being relayed to a program. In certain cases the program can specify whether to convert (from 6-bit to ASCII, or from ASCII to 6-bit) or not; see individual system calls in LTSS-9.

Table 1 should help in translating among Teletype keys, ASCII codes, 6-bit code, and Teletype printing. See also Table 3, which lists the 6-bit code input when any Teletype key is used alone or in combination with one or both of the Shift and Control keys. The columns of this chart are arranged as is the Teletype keyboard. An entry of "NOP" indicates that the indicated key combination cannot be depressed because of keyboard interlocks.

FROST makes one further change in all input messages. It converts any end-of-message character: linefeed (LF; 012), end of transmission (EOT; 004), or end of transmission block (ETB; 027), to 6-bit end of transmission (400204) and ignores any subsequent character. Note that this overrides the Tentacle convention (section 1.3.4) that preserves the end character and may insert an ETB (400227). FROST also inserts an EOT (400204) after every output message.

As an example, consider the input message,

A BEL ENQ 4 @ LF,

which in ASCII is

101 007 005 064 100 012.

In 6-bit code it becomes

41 40 02 07 40 02 05 24 40 03 00 40 02 04.

Table 3. The Teletype keyboard and LLL 6-bit code

	1 !	2	3 #	4 \$	5 %	6 &	7	8 (	9)	0	: *	- =	HERE IS
	21	22	23	24	25	26	27	30	31	20	32	15	Answer back
Shift	01	02	03	04	05	06	07	10	11	NOP	12	35	Answer back
CTRL	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	Answer back
CTRL Shift	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	Answer back

	ESC	Q	W	WRU E	TAPE R	TAPE T	Y	U	TAB I	← O	@ P	LINE- FEED	RE- TURN
	400233	61	67	45	62	64	71	65	51	57	60	400204	400215
Shift	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	77	400300	NOP	NOP
CTRL	400233	400221	400204	400205	400222	400224	Message cancel	400225	400211	400217	400220	400204	400215
CTRL Shift	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	NOP	400237	Break	NOP	NOP

	A	XOFF S	EOT D	RU F	BELL G	H	J	[K	FORM L	+ ;	RUB OUT	REPT	BREAK
	41	63	44	46	47	50	52	53	54	33	NONE	Repeat	Break
Shift	NOP	NOP	NOP	NOP	NOP	NOP	NOP	73	74	13	NOP	Repeat	Break
CTRL	400201	400223	400204	400206	400207	400210	400212	400213	401214	NOP	NOP	Repeat	Break
CTRL Shift	NOP	NOP	NOP	NOP	NOP	NOP	NOP	400233	400234	NOP	NOP	Repeat	Break

	Z	X	C	V	B	↑ N	↓ M	< ,	> .	? /			SPACE BAR
	72	70	43	66	42	56	55	14	16	17			00
Shift	NOP	NOP	NOP	NOP	NOP	76	75	34	36	37			NOP
CTRL	400232	Char. cancel	400203	400226	400202	400216	400215	NOP	NOP	NOP			NOP
CTRL Shift	NOP	NOP	NOP	NOP	NOP	400236	400235	NOP	NOP	NOP			NOP

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Similarly, an output message in 6-bit code,

41 40 02 05 24 40 02 12 40 02 04,

becomes in ASCII

101 005 064 012 004,

which prints as

A answer-back 4 LF EOT (window).

The input occasioned by answer-back operation will begin echoing after the EOT character (004) opens an echo window (see section 1.4.1).

3.2 ID LINE

The ID message format demanded by the FROST System is the following:

IDX NNNNNN_^S_^MMMAAA_^L_^ (CTRL-Z)CCCCC (linefeed)

- | | |
|--------|---|
| IDX | The message must begin with "ID" and the designator of the computer in which the FROST System is operating. This group should be followed by a single space. (Note that "ID" and the following space are provided and echoed by the Tentacle computer when the machine designator is entered.) |
| NNNNNN | The six-digit decimal user number (leading zeroes not suppressed) should appear next. Your user number is the same as your employee number, and informs FROST who is using the teletypewriter. FROST checks the number against an authorization list. The user number must be followed by a space. |
| S | The next character, called the suffix , must be one of the letters A, B, C, or D. (E can be used, but it is internally translated to D.) The suffix indicates that program with which you want to converse (under FROST, you may run up to four programs simultaneously). That is, each program may be identified by a user number and suffix. The FROST system on each CDC 6600 is independent of the others, so you may use the same suffix on two or more different machines. A space must follow the suffix. |
| MMMAAA | This group of three digits followed by three letters defines an account to which your computer time should be charged. A blank or an end-of-message character must follow the account designation. |
| L | The security level is optional. It can be any one of the characters: U, P, A, S, or K. The default is P. |
| CCCCC | A security combination may be added to the ID message after the account number (or level). The combination is typed in echo-suppress mode (see section 1.3.8): type (CTRL-Z)(this will print as %), followed by the combination. The six characters of the combination will also print at % symbols. |

Some examples of ID messages follow:

IDG 123000 A 111PPP (linefeed)
 IDM 471762 B 672BCD U (linefeed)
 IDL 471762 C 672BCD %%%%%%%%% (linefeed)
 IDM 173494 D 564SIE A %%%%%%%%% (linefeed)

3.3 RESPONSES TO THE ID LINE

The level of FROST that communicates with Tentacles responds to a valid ID line with a bank-account designation, the state of any job in progress, the highest waiting priority, and the security level (if higher than P). You may assume that you are logged in if you do not receive one of the following error responses within a few seconds:

NO ID	The message did not begin with "ID" and machine designator; or, the message was received by a 6600 other than the one designated; or, the Tentacle did not think the message was an ID message. This error may result from a disagreement in system records between Tentacle and worker. Try the ID message again.
NOT A USER ON TTY <i>nnnn</i>	The user number that you typed is not valid. FROST regards you as being logged in to the same worker on teletypewriter <i>nnnn</i> . You must log off from one teletypewriter before using another. If this message results from record confusion, a retry of the ID message should be successful. However, there are a few cases that the current system cannot handle. Contact Systems Operation Section if FROST repeatedly insists that you are on a teletypewriter which you are not using.
BAD SUFFIX	The suffix is not A, B, C, D, or E.
ACCOUNT	The account designation is not valid.
TOO MANY USERS	There are already 100 users in the system, the maximum number allowed.
NO TIME MASTER ACCOUNT	There is no bank-account time available for you in your master account.
BAD ACCESS CODE	The access code you typed is not U, P, A, S, or K.
ACCESS CODE TOO HIGH	The access code is higher than the allowable maximum level designated for your user number.
USE COMBO	FROST expected a combination and failed to find one.
COMBO BAD	An incorrect combination was typed.
ACCESS CODE TOO LOW	A problem is already running under this suffix (e.g., a job you left running upon last logging off), with an access code higher than the one you just typed in.
NO CONTROL Z	FROST tried to interpret typed information as a combination, but this information was not preceded by a SUB(CTRL-Z) character.

Other responses, such as NO FILE, indicate that both Tentacle and worker regard the teletypewriter as already logged in. To log out, type the EOT character (CTRL-D).

An additional "broadcast" message from the computer operator may be sent to the teletypewriter after an ID message (see section 1.5.3).

3.4 BREAK

Certain input messages are always intercepted by FROST. The break message is one such message. If you have no problem program running, FROST will respond with: NO PP. Otherwise,

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it will respond with: **BREAK**. This response indicates that execution of the problem program has been terminated. If the program is a controllee of another program, the controller will continue to run. It may in turn be stopped with another break. (Remember, each mild oath echoed by a Tentacle corresponds to exactly one break message.)

A "broken" problem program may be restarted with an execute line (see section 3.10) and will continue where it left off. However, all I/O devices except disk and teletypewriter are disconnected from the program by a break.

3.5 QUESTION LINE

Once you have attracted the attention of FROST by logging in, you may wish to know what is currently happening under this number and suffix. The current status of this user number (and suffix), including the status of any problem programs being run, may be obtained by typing the **question line**. FROST will respond with your bank account, the time and date, the status of any problem program being executed or waiting to be executed, and the highest waiting priority. Omission of the status message indicates that no problem program is currently active.

Format: type

? (linefeed) or

(CTRL-E)? (linefeed)

Here (CTRL-E) represents pressing the E key while the Control key is held down.

Response: FROST replies with one or two lines of typing (two lines if there is an active problem program, one line if not). The first line is of the form:

BANK = XXXX.XXXX NN:DD:HH:MM:SS or

BANK = XXXX.XXXX NN/DD HH:MM:SS

where

X is the amount of time currently available to you, given in minutes;

N, D is the date. The month and day are given as integers;

H, M, S is the time of day, in hours, minutes, and seconds.

Example: BANK = 0014.99791 11/29 13:45:11 means that there was almost fifteen minutes available to this user at 1:45 P.M., November 29.

If a problem program is active under your user number, FROST also types an additional line of information giving the status of the problem program. There are two possibilities for this line.

RUNNING The problem program is now running in the 6600 central processing unit.

STATE = NN The problem program is not now running for reason NN, and has been returned to disk.

NN = 11 There is not enough core memory available for the problem program.

NN = 12 The problem program is waiting for a non-disk I/O device to be created.

NN = 13 The problem program is waiting for an I/O device to be destroyed.

NN = 14 The problem program is waiting to send a message to its controller.

NN = 15 The problem program is waiting to send a message to its controllee.

NN = 16 The problem program is waiting to receive a message from its controller or from the teletypewriter.

NN = 17 The problem program is waiting to receive a message from its controllee.

NN = 22 The program is waiting to send a message to the PDP-10.

NN = 23 The program is waiting for a message from the PDP-10.

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NN = 31 The problem program has been suspended at its own request for a given time period.

NN = 77 The problem program is finished, and FROST is waiting to send the message: ALL DONE.

3.6 OTHER SYSTEM-INTERROGATION LINES

3.6.1 State of Problem Program Line

Use this line to get the state information that is the heart of the question line. Format: (CTRL-E)S (linefeed)

Response:

STATE = NN

The states are as listed in section 3.5.

3.6.2 Active-Suffix Line

Use this line to determine which suffixes under this user number have active programs. Format:

(CTRL-E)SU (linefeed)

FROST responds with a list of one or more of the letters A to D. If a suffix letter is listed then there is a descriptor block assigned for that suffix.

3.6.3 Time Line

This line is used to find the time of day. Format:

(CTRL-E)T (linefeed)

Response:

MM/DD HH:MM:SS

The month and day are given, as well as the current clock time in hours, minutes, and seconds.

3.6.4 Protection-Level Line

You can determine the protection level that you logged in under by using this line. Format:

(CTRL-E)LL (linefeed)

FROST responds with one of the following pairs: U-1, P-2, A-3, S-5, or K-7.

3.7 BANK-ACCOUNT LINE

The purpose of the bank-account line is to obtain the current status of the bank account. Format:

(CTRL-E)BB (linefeed)

Response:

BANK = XXXX.XXXXX

where X is the amount of time currently available to you, given in minutes.

Example: BANK = 0010.50000 means that the user has ten minutes and thirty seconds left in his bank account.

3.8 PRIORITY-CHANGE LINE

This line is used to change the priority of the program running under the current suffix.
Format:

(CTRL-E)PC^XX.XXXX (linefeed)

The value of XX.XXXX must be in the range from 0.1 to 5.0. There must be a space between the PC and the first digit of the new priority value. FROST does not reply to the priority-change line, even if for some reason (e.g., the space between PC and the first digit is missing) the priority change cannot be made. If the value is too low, FROST will change the priority to 0.1 (or to 1 during production hours); if too high FROST will change the priority to 5.

3.9 BYE LINE

After you have temporarily finished using FROST and wish to terminate the connection between the teletypewriter and your user number, you should type the **bye line**. If you wish to cease operating under the suffix you are now using, and to run under a different suffix, you should type the bye line with a suffix.

Format: (CTRL-D)(linefeed)

or BYE (linefeed)

BYE X (linefeed)

or (CTRL-E)X (linefeed)

If FROST receives the message EOT (i.e., CTRL-D) or BYE from a teletypewriter, it severs all connection between that teletypewriter and that user number and will respond with: BYE. If there is an active problem program when BYE is received, it remains active until it terminates or sends a message to the teletypewriter. If a message is sent to the teletypewriter by the problem program while the user is logged out, either the problem program is suspended until the user logs in, or the problem program continues to run and the message is thrown away by FROST, or the problem program continues to run and the message replaces any previous message waiting to go to the teletypewriter. The choice is left up to the problem program (see LTSS-9). FROST responds with: BYE.

If FROST receives the message BYE X (where X is A, B, C, D, or E), it severs all connection between the teletypewriter and the user number under its current suffix, and initiates the connection under the new suffix. FROST should respond with BYE X, the state of any program running under the new suffix, and the highest waiting priority.

If FROST should respond instead with BYE, the new suffix has not been recognized and you have been logged out; an ID line is necessary to reenter the system. Note that BYE X is equivalent to BYE followed by a new ID line for the same machine.

3.10 EXECUTE LINE

You will probably use the Octopus System to run programs. Execution of a problem program is initiated by using the **execute line**. While a program is running you may communicate with it by using the **message line** to send messages to the problem program, and by reading messages sent by the problem program. When the problem program has finished running, FROST will send the message ALL DONE to the teletypewriter (see section 3.3.13).

The following line represents the format of an execute line:

NAME *message* / *t v* (linefeed).

NAME The first item on the execute line is the name of the problem program that you wish to use, followed by a space. The name will be checked by FROST. If there is no private file by that name under this user number, and if no public file by that name exists (that is, if there is no such problem program), an error message will be sent to the teletypewriter. The name may be any length from one to ten characters, inclusive, and may include any character but a blank (since a blank is used to signal the end of the name to FROST).

message Most problem programs require some information before they can begin execution (such as the name of a file to operate on); many such problem programs will accept a message on the execute line. As far as FROST is concerned, this message may consist of any characters (including blanks) except the trio: blank, slash, blank. FROST will automatically attach an EOT character to the message. The problem program will have restrictions of its own, of course. If the problem program does not require a message to begin, this portion of the execute line may be omitted.

$\wedge / \wedge$ The space-delimited slash is used as a signal to FROST that the message to the problem program is completed, and that all following information is special system data.

t The first item of this special system data is the maximum amount of CPU time (in minutes) that you wish this problem program to run, and is termed the **time limit**. It may be a fixed-point integer or a decimal fraction. When the problem program has run this long, FROST will stop execution of this problem program* and send an appropriate comment to the teletypewriter. The problem program may be restarted with a new time limit, provided no input/output devices (other than disk and teletypewriter) are connected to it.

v The second item of the special system data is the maximum amount of time (in minutes) that you wish to be charged for the execution of this problem program. This **value** may be a fixed-point integer or a decimal fraction. It is used to calculate a **priority** $p = v \div t$, where *v* and *t* are as defined. If the problem program actually executes for *T* minutes, the user's bank account will be charged $p \times T$ minutes of CPU time. The priority *p* is also used as a criterion for determining the order in which problem programs are run by FROST. Note that in addition to the charge for CPU time, there is also a charge for input/output and certain system services.

Examples of execute lines: COPY FILE1 FILE2 / 1 1
DESTROY COMPLETELY ALL / 2 .2
FILES / 1 .4

* Unless a "change-time-limit" call is given by the problem program; see LTSS-9.

3.11 RESPONSES TO THE EXECUTE LINE

If no errors are detected in the execute line, the problem program will be initiated. The only teletypewriter response in this case is the normal carriage return. If there is a problem program already running under this user number and suffix, this line will be treated as a message line (see section 3.12).

NO FILE	The name given does not exist as a disk file, or the disk file does not belong to this user number and is not a public file.
NO SLASH	A space-delimited slash must appear before time limit and value. Retype the execute line.
NO TL	The time limit given is of incorrect format. Retype the execute line.
NO VALUE	The value given is of incorrect format. Retype the execute line.
LOG IN	You did not log in before typing the execute line.
FILE TOO SMALL	The file size of the program you wish to execute is less than 402 (octal) words.
FILE TOO LARGE	FROST limits a program to a maximum size of 100,063 (decimal) words.

Any other message usually means that there is a problem program running under this suffix and ID. Type ? before typing your first execute line to ensure that this won't happen. Wrong input can be disastrous to a running problem program.

If the system No Execute flag is on, you may get a message response to your execute line. The contents of this message are determined by the computer operator at the time he sets the flag. It means that the system will not honor any new executions, and is usually set in preparation for a scheduled dead start.

3.12 MESSAGE LINE

Any teletypewriter line — regardless of format — that is not any of those described in sections 3.2 through 3.11 is, by definition, a **message line**. Also, by definition, a message line is a line to be read (as input data) by an active problem program. FROST does not examine a message line. FROST will save the first message line that has been sent until the problem program has asked for it or until the problem program ceases to be active. If several messages are sent before the problem program has asked for a message, only the first such message is saved. If the problem program has a message to send to the teletypewriter and it has not yet been sent, incoming messages from the teletypewriter are discarded. If the problem program has a message waiting from its controllee that has not been picked up, any incoming teletypewriter messages will be discarded, and the following message is sent to the teletypewriter: TRY AGAIN.

The methods by which problem programs communicate with FROST, including the transmission of teletypewriter messages, are detailed in LTSS-9.

3.13 ALL-DONE LINE

The following message is sent by FROST when a problem program has terminated:

ALL DONE

Termination can be caused by any of the following conditions:

- The problem program has told FROST that it is finished.
- The Break key has been struck.

- The problem program has exceeded the time limit. In this case, the following comment is also sent to the teletype, preceding ALL DONE:

NO TIME LEFT FOR *programe*

(where *programe* is the name of the problem program).

- A fatal error has occurred in the problem program. In this case, the comment

PROBLEM ERROR XXX

will be sent to the teletype, where XXX is the error number defined in LTSS-9.

- An input or output fatal error has occurred. In this case, the comment

IO ERROR 30X YYYYYY NNNNNNNNNN MES

will be sent to the teletype, where

30X is the error number.

YY...Y is the address of the I/O request.

NN...N is the file name. (If the minus word pointed to by the IOD is zero, then this field will be "VOID NAME.")

MES is one of the following error messages:

ILLEGAL IOD

ILLEGAL JOB

BAD MEM. ADD.

BAD DISC ADD.

IS READ ONLY

WRITE PARITY

BAD MINUS WORD

- The problem program has no exchange-jump packages, or has too many, or exchange packages are garbled. The following message is sent before the ALL DONE:

PROBLEM ERROR 207.

(This usually indicates that the file to be executed is a data file.)

- A hardware error has occurred.

An ALL-DONE line indicates that the problem program referred to on the execute line is no longer active. A new execute line may now be typed.

4. FLOE (CDC 7600) Operation

4.1 CHARACTER CODES

FLOE represents characters in the same 6-bit ASCII scheme as the one used by FROST. See section 3.1 and Tables 1 and 3 in this chapter for details; see also LTSS-0.

FLOE converts messages generated by running problem programs from 6-bit to ASCII before passing them on to a Tentacle. Conversely, messages received from a Tentacle are converted to 6-bit before being relayed to a program. In certain cases the program can specify whether or not the conversion (in either direction) should be made; see the individual system calls described in LTSS-10.

FLOE observes the same convention as FROST does regarding end-of-message characters: it converts all LF (012), EOT (004), and ETB (027) characters to 6-bit EOT (400204). See the example in section 3.1.

4.2 ID LINE

The ID message format that FLOE expects is identical to the format demanded by FROST. See section 3.2.

Examples of ID lines are*:

IDR 123400 A 111PPP (linefeed)

IDS 471672 C 672BCD U (linefeed)

IDT 967400 D 237PAD S %%%%%%%%%% (linefeed)

4.3 RESPONSES TO THE ID LINE

The level of FLOE that communicates with Tentacle computers will respond to a valid ID message with a message of the form:

X BBBB.BBB ACTIVE *list*

where

X is the machine letter designator,

BBBB.BBB is the time you are currently eligible to use from the repository account,

ACTIVE is verbatim, and

list is NONE or a list of currently active suffixes for this user.

If you are reentering the system after having logged out while a job was still active, the response to a valid ID message will simply be the activity state of any job under the suffix stated on the ID line (see section 4.5):

ste progname

If no job is active, the response will be

NIL.

*N.B.: the user types the machine letter designator (R, S, or T), and it is echoed as: the characters "ID," the typed letter, and a space.

Certain error messages may be sent in response to an ID message (log-on line). They all indicate that you are not logged in. These messages are as follows:

NO ID	A log-on line has been received by a 7600 other than the machine specified in that log-on line.
NOT A USER!	The user number specified in the log-on line is not recognized as legitimate.
BAD SUFFIX	An improper suffix was specified in the log-on line.
ACCOUNT	An improper or illegal account code was specified in the log-on line.
ON TTY <i>nnnn</i>	FLOE considers you to be logged on to terminal <i>nnnn</i> .
SYSTEM TABLES FULL. TRY AGAIN.	Some system table(s) is (are) full, and the system will not accommodate any more users. This is a temporary condition.
DRUM FILE INDEX PURGE IN PROGRESS. TRY AGAIN.	User files are being examined for lifetime expiration. Log-on is inhibited until purge is complete.
BAD ACCESS CODE	You have specified an improper or denied protection level.
BAD COMBINATION	Either you have not correctly typed your combination, or you have failed to type a combination when the system requires one.
ACTIVE AT HIGHER PROTECTION LEVEL	You had previously logged on at a protection level higher than that specified in the current log-on line, and had left an active program in the computer upon logging off. You must log on at a protection level equal to or greater than that of any currently active suffix.

Some other responses may occur, most notably [BYE]. (This message may occur at any time, not only at log-on time.) It implies that there is a disagreement between the PDP-8 and the worker as to whether your teletypewriter is logged in. You should be able to log in again at once.

A clear-text message of variable content may be received (see section 1.5.3). It will usually be a self-explanatory message from the operator indicating that he has inhibited time-sharing.

Any other response indicates that both Tentacle and worker regard the teletypewriter as already logged in. To log out, type BYE or CTRL-D (the latter is preferred).

4.4 BREAK

FLOE intercepts all break messages. Its response to a break message is identical to that of FROST; see section 3.4.

4.5 QUESTION LINE

Once you have attracted the attention of FLOE by logging in, you may wish to know what is currently happening under this number and suffix. You can determine the current status of this user number, including the status of any problem programs being run, by typing the **question line**. FLOE will respond with your bank account, the time and date, the status of any problem

program being executed or waiting to be executed, and the name of that program. Omission of the status message indicates that no problem program is currently active.

Format: type
? (linefeed) or
(CTRL-E)? (linefeed)

Here (CTRL-E) represents the simultaneous pressing of the control key and the E key. FLOE will respond with:

XMO/DA HH.MM:SS BBBB.BBBB STE *programe*

where

X	is machine letter designator,
MO	is month,
DA	is day,
HH.MM:SS	is the current clock time (hours, minutes, and seconds),
BBBB.BBBB	is the current time, in minutes, in your account,
<i>ste</i>	is the code indicating the state of a job under this suffix (listed below), and
<i>programe</i>	is the name of the job.

If no program is running under the logged-in suffix, *ste* will be NIL. Other state codes are:

RUN	The program is in Large Core Memory (LCM).
MEM	The program is awaiting the availability of LCM.
TPE	The program is waiting for a tape drive to be assigned.
RCV	The program is waiting to receive a message from its controller (another program or the teletypewriter).
XMT	The program is waiting to send a message to its teletypewriter.
SUS	The program has been suspended at its own request for a given time period.
PDP	The program is waiting to receive a message from the PDP-10.
FIN	The program is finished and FLOE is waiting to send the message: ALL DONE (see section 3.4.16).
13*	The program is waiting for a tape to be released.
15*	The program is waiting to send a message to its controllee.
17*	The program is waiting to receive a message from its controllee.
44	The program is waiting for system-buffer space to send a message to the PDP-10.
46	The program is waiting for system-buffer space to send a message to the operator's teletypewriter.

In the case of a controller-controllee program chain where no job in the chain is running, the state code given will apply to the lowest-level job in the chain. If any job in the chain is running, the RUN state will be given.

* These states are transient and have, normally, millisecond lifetimes, so that the user might reasonably expect never to encounter them.

4.6 OTHER SYSTEM-INTERROGATION LINES

4.6.1 State of Problem Program Line

Format:

(CTRL-E)S (linefeed)

Response:

ste progame

where *ste* and *progame* are as described in section 4.5, above.

4.6.2 Active-Suffix Line

This line is used to determine which suffixes under this user number have active programs.

Format:

(CTRL-E)SU (linefeed)

FLOE responds with a list of one or more of the letters A through E, representing suffixes to which descriptor blocks are assigned (allowing execution of a job). There may or may not be a program actually executing under each listed suffix, but the appearance of a letter indicates some activity under that suffix.

4.6.3 Time Line

This line is used to determine the time of day. Format:

(CTRL-E)T (linefeed)

FLOE responds with

Xmm/dd HH.MM:SS

giving the machine, month, and day, as well as the current clock time in hours, minutes, and seconds.

4.6.4 Protection-Level Line

You can determine the protection level that you logged in under by using this line. Format:

(CTRL-E)LL (linefeed)

Response:

ACCESS X-Y

Here ACCESS is verbatim, and X-Y is one of the following: U-1, P-2, A-3, S-5, or K-7.

4.6.5 Priority-Queue Lines

These lines give the highest priority of any job in the job-waiting queue, and the length of the queue. Format:

(CTRL-E)PR (linefeed) or

(CTRL-E)PQ (linefeed)

Response:

```
HI PR IN Q =
n.nnnn
Q LENGTH =
nnn
```

The PQ option will give the queue of jobs in LCM and in the memory-wait state, while use of the PR option will give information on all jobs that are waiting, including those in tape-wait and message states (see section 4.5).

4.7 BANK-ACCOUNT LINES

You can find out how much time is currently available to you or to your pool by typing one of the bank-account lines.

4.7.1 Pool Bank-Account Line

Format:

```
(CTRL-E)BP (linefeed)
```

The response of FLOE to this line is

```
BBBB.BBBB
```

where B is the total time, in minutes, in your pool repository.

4.7.2 Pool Available-Time Line

Format:

```
(CTRL-E)BA (linefeed)
```

Response:

```
BBBB.BBBB
```

where B is the **available time** in the pool repository, i.e., the total repository time minus the total **claimed time**. The claimed time for the pool is the total of all $t \times p$ values (i.e., v values) for all active user numbers in the pool, and all active suffixes. See the section on Execute Lines (4.13) for definitions of t , v , and p .

4.7.3 User Eligible-Time Line

Format:

```
(CTRL-E)BE (linefeed)
```

Response:

```
BBBB.BBBB
```

where B is the amount of time you are eligible to use; this figure is equal to the pool bank-account time multiplied by your percentage eligibility.

4.7.4 User Claimed-Time Line

Format:

(CTRL-E)BB (linefeed)

Response:

BBBB.BBBB

where B is your remaining claimed time (for all active suffixes); equal to the sum of your v values minus the time you have been charged (see below).

4.7.5 User Charged-Time Line

Format:

(CTRL-E)U (linefeed)

Response:

BBBB.BBBB

where B is the amount of time you have been charged, i.e., the amount of time withdrawn from the pool account during that accounting day.

FLOE may send one of the following messages during execution of a problem program named *progrname*:

NO TIME LEFT FOR *progrname*

Either the job has exceeded its time limit t (see section 4.13) or has exhausted its repository account eligibility.

BANK UPDATE. JOB *progrname* KILLED.

During the execution of the program there was a repository update and/or a directory update; as a result you are not eligible to charge any more time.

4.8 PRIORITY-CHANGE LINE

Use this line to change the priority p of all jobs under the current suffix. Format:

(CTRL-E)PC n.n (linefeed)

FLOE responds with [OK]; if the priority value n.n that you have specified is greater than the system maximum priority, or less than the system minimum, FLOE replies: OUT OF RANGE, and the priority change is not made. If n.n is acceptable, all jobs in memory are given chargeable dumps and are requeued for the new priority. The quantity n.n must be numeric.

4.9 POOL LINES**4.9.1 Active-Pool Line**

This line is used to obtain a list of your active file pools. See the *Computer Security Manual* for information about file pools. Format:

(CTRL-E)LP (linefeed)

FLOE responds with a list of the names of active pools.

4.9.2 Pool Connect/Disconnect Lines

To connect to an authorized disk-file pool, type:

(CTRL-E)POOL *poolname* (linefeed)

To disconnect from the disk-file pool, type:

(CTRL-E)POOL -*poolname* (linefeed)

Note that an arithmetic minus sign must be typed before the *poolname* to disconnect.

FLOE makes no reply if the pool connection is made. Several error messages may result:

NO POOL

You are trying to connect to a non-existent file pool.

ONLY 5 ACTIVE POOLS ALLOWED

You are trying to connect to too many pools.

CAN'T LOAD POOL BOSS FROM DRUM

You are trying to connect to a file pool whose boss is not currently logged in, *and* the system is unable to load the pool-boss index from the system drum.

4.10 SEND A MESSAGE TO OPERATOR LINE

Format:

(CTRL-E)OP *text* (linefeed)

The system replies [OK] and the *text* is sent to the operator's console teletypewriter. Note: utility routine SAMTOP (UR-304) can be used for the same purpose.

4.11 TELETYPEWRITER-ENABLE LINE

If you suspect that your teletypewriter is malfunctioning, you can request FLOE to send it an enable message. Type (CTRL-E)X (linefeed). FLOE will send the message but will not make a reply.

4.12 BYE LINE

After you have temporarily finished using FLOE and wish to terminate the connection between the teletypewriter and your user number, you should type the **bye line**. If you wish to cease operating under the suffix you are now using, and to run under a different suffix, you should type the bye line with a suffix.

Format: (CTRL-D) (linefeed)

or BYE (linefeed)

BYE X (linefeed)

or (CTRL-E)X (linefeed).

If FLOE receives the message EOT (i.e., CTRL-D) or BYE from a teletypewriter, it severs all connection between that teletypewriter and that user number, and will respond with: BYE. If there is an active problem program when BYE is received, it remains active until it terminates or sends a message to the teletypewriter. If a message is sent to the teletypewriter by the problem

program while the user is logged out, either the problem program is suspended until the user logs in, or the problem program continues to run and the message is thrown away by FLOE, or the problem program continues to run and the message replaces any previous message waiting to go to the teletypewriter. The choice is left up to the problem program. See LTSS-10.

If FLOE receives the message BYE X (where X is A, B, C, D, or E), it severs all connection between the teletypewriter and the user number under its current suffix, and initiates the connection under the new suffix. FLOE should respond with: BYE X.

If FLOE should respond instead with BYE, the new suffix has not been recognized and you have been logged out; an ID line is necessary to reenter the system. Note that BYE X is equivalent to BYE followed by a new ID line for the same machine.

4.13 EXECUTE LINE

You will probably use the Octopus System to run programs. Execution of a problem program is initiated by using the **execute line**. While the program is running, you may communicate with it by using the **message line** to send messages to the problem program, and by reading messages sent by the problem program. When the problem program has finished running, FLOE will send the message ALL DONE to the teletypewriter (see section 4.16).

The following line represents the format of an execute line:

NAME *message* / *t* *v* (linefeed).

NAME The first item on the execute line is the name of the problem that you wish to use, followed by a space. The name will be checked by FLOE. If there is no private file by that name under this user number, or in any pool of files to which this user is connected, and if no public file by that name exists (that is, if there is no such problem program), an error message will be sent to the teletypewriter. The name may be any length from one to ten characters, inclusive, and may include any character but a blank (since a blank is used to signal the end of the name to FLOE).

message Most problem programs require some information before they can begin execution (such as the name of a file on which to operate); many such problem programs will accept a message on the execute line. As far as FLOE is concerned, this message may consist of any characters. FLOE will automatically attach an EOT character to the message. The problem program will have restrictions of its own, of course. If the problem program does not require a message to begin, this portion of the execute line may be omitted.

^/^ The space-delimited slash followed by *t* and *v* and an EOT signal is used as a signal to FLOE that the message to the problem program is complete, and that everything following is special system data.

t The first item of this special system data is the maximum amount of CPU time (in minutes) that you wish this problem program to run, and is termed the **time limit**. It may be a fixed-point integer or a decimal fraction. When the problem program has run this long, FLOE stops executing this problem program* and sends an appropriate comment to the teletypewriter. The problem program may be restarted with a new time limit, provided no input/output devices (other than disk and teletypewriter) are connected to it.

* Unless a "change-time-limit" call is given by the problem program; see LTSS-10.

ν The second item of the special system data is the maximum amount of time (in minutes) that you wish to be charged for the execution of this problem program. This **value** may be a fixed-point integer or a decimal fraction. It is used to calculate a **priority** $p = \nu \div t$, where ν and t are as defined. If the problem program actually executes for T minutes, the user's bank account is charged $p \times T$ minutes of CPU time. The priority p is also used as a criterion for determining the order in which problem programs are run by FLOE. Note that in addition to the charge for CPU time, there is also a charge for input/output and certain system services.

Examples: COPY FILE1 FILE2 / 1 1
DESTROY COMPLETELY ALL / 2 .2
MYPROG DATAFILE 4.5 / 7 5

4.14 RESPONSES TO THE EXECUTE LINE

If no errors are detected in the execute line, the problem program will be initiated. The only teletypewriter response in this case is the normal carriage return. If there is a problem program already running under this user number and suffix, this line will be treated as a message line (see next section). Possible error messages are:

NO FILE	The name given does not exist as a disk file; or, the disk file is not accessible to your user number and is not a public file.
BAD FILE SIZE	The file specified for execution is less than 231 octal words long or is larger than all available LCM (1,414,600 words).
NON-EXECUTABLE FILE	The indicated file is type Data.
NO SLASH	There is no space-delimited slash on the execute line before the time limit and value.
NO TL	The time limit t is of incorrect format, or is missing.
TL TOO LARGE	The specified time limit, when converted to microseconds, would occupy more than 36 bits of storage ($t \gtrsim 1145$ min.).
NO VALUE	The value ν is of incorrect format, or is missing.
LOG IN	You did not log in before typing the execute line.
OVERCHARGE!	You have exhausted your allowed percentage of the repository time.
NOT ENUF TIME IN REPOSITORY.	The repository account doesn't contain sufficient time to support the time limit and priority specified.
USER NUMBER DELETED. LOG OFF.	Some time during the current terminal-connect time, there was a modification to the system user directory, and as a result FLOE no longer recognizes your user number as legal.
?SAY AGAIN?	FLOE cannot decode the typed message into a meaningful enquiry line.

Any other message usually means that there is a problem program running under this suffix and ID. You can use the question line before typing your first execute line to ensure that this won't happen. Wrong input can be disastrous to a running problem program.

4.15 MESSAGE LINE

Any teletypewriter line — regardless of format — that is not any of those described in sections 4.2 through 4.14 is, by definition, a **message line**. Also, by definition, a message line is a line to be read (as input data) by an active problem program. FLOE does not examine a message line. FLOE will save the first message line that has been sent until the problem program has asked for it or until the problem program ceases to be active. If several messages are sent before the problem program has asked for a message, only the first such message is saved. FLOE can, however, handle simultaneous messages to a program from teletypewriter and controllee.

The methods by which problem programs communicate with FLOE, including the transmission of teletypewriter messages, are detailed in LTSS-10.

If a program is in a PDP state, waiting for a message from the PDP-10, it can be interrupted from the teletypewriter. The act of typing in a message will activate the program.

If, however, the program is in an RCV state, waiting for a message from the teletypewriter, and a message comes from the PDP-10 for that program, the message will not cause an interrupt. The PDP-10 message will be saved for the program until it asks for it.

4.16 ALL-DONE LINE

The following message is sent by FLOE when a problem program has terminated:

ALL DONE

Termination can be caused by any of the following conditions:

- The problem program has told FLOE that it is finished.
- The Break key has been struck.
- The problem program has exceeded the time limit. In this case, the following comment is also sent to the teletype, preceding ALL DONE:

NO TIME LEFT FOR *programe*

- A fatal error has been detected by FLOE. It will send a message to the teletypewriter saying: ERROR NNN *text* where NNN is an error code defined in LTSS-10. The *text* is a brief statement regarding the nature of the error, the location at which it occurred, and the name of the program suffering the error.
- A hardware error has occurred.

An ALL-DONE line indicates that the problem program referred to on the execute line is no longer active. A new execute line may now be typed.

Suggested Reading

- J. G. Fletcher, *Livermore Time-Sharing System*, Chapter 0: "Octopus," Lawrence Livermore Laboratory, Rept. LTSS-0 (1970).
- P. Du Bois and J. D. Lawrence, *Livermore Time-Sharing System*, Chapter 9: "6600 System Calls and I/O Requests," Lawrence Livermore Laboratory, Rept. LTSS-9 (Edition 3, changed 1971).
- P. Du Bois, H. Coverston, D. Storch, and G. Powles, *Livermore Time-Sharing System*, Chapter 10: "7600 System Calls and I/O Requests," Lawrence Livermore Laboratory, Rept. LTSS-10 (Edition 4, changed 1971).
- D. Thompson, *Utility Routine SAMTOP*, Lawrence Livermore Laboratory, Rept. UR-304 (1970).
- Computer Security Manual*, Lawrence Livermore Laboratory, Rept. M-032 (1972).
- Gator Users' Manual*, an unpublished, informal document; see J. G. Fletcher for a copy.

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